

CLAIMS

What is claimed is:

1. A wafer-level package for a micromirror array, the wafer-level package
5 comprising:
 - a substrate comprising a wafer having a substrate surface;
 - a plurality of actuatable micromirrors coupled to the substrate surface; and
 - an optical window attached to the substrate surface to form at least one sealed
cavity between an inner surface of the optical window and the substrate surface, wherein a
10 beam of light transmitted through the optical window is redirected by at least one actuatable
micromirror within the at least one sealed cavity.
2. The wafer-level package of claim 1, wherein the plurality of actuatable
micromirrors is coupled to the substrate surface with at least one vertical comb drive
15 electrostatic actuator.
3. The wafer-level package of claim 1, wherein the substrate comprises a silicon
wafer.
- 20 4. The wafer-level package of claim 1, wherein the optical window comprises
one of a glass wafer or a silicon wafer.

5. The wafer-level package of claim 1, wherein the at least one sealed cavity has a cavity height greater than 100 micrometers.

6. The wafer-level package of claim 1, wherein the optical window is attached to the substrate with one of a solder bond, a thermocompression bond, or a wafer-to-wafer bond.

7. The wafer-level package of claim 1, wherein the optical window comprises at least one molded recess to form at least a portion of the at least one sealed cavity.

8. The wafer-level package of claim 1, wherein the optical window is attached to the substrate surface via a spacer between the inner surface of the optical window and the substrate surface.

9. The wafer-level package of claim 8, wherein the spacer comprises plated nickel.

10. The wafer-level package of claim 1 further comprising:
at least one cap reflector disposed on the inner surface of the optical window.

11. The wafer-level package of claim 1 further comprising:
at least one cap reflector disposed on a surface of the optical window opposite the at least one sealed cavity.

12. The wafer-level package of claim 1 further comprising:
a cap lens attached to the optical window on a surface opposite the at least one sealed cavity.

5 13. The wafer-level package of claim 12 further comprising:
at least one cap reflector disposed on a surface of the cap lens between the cap lens and the optical window.

10 14. The wafer-level package of claim 12 further comprising:
a transparent shim positioned between the cap lens and the optical window.

15. The wafer-level package of claim 14 further comprising:
at least one cap reflector disposed on a surface of the transparent shim.

15 16. The wafer-level package of claim 1 further comprising:
an anti-reflective coating disposed on the inner surface of the optical window.

17. The wafer-level package of claim 1 further comprising:
an anti-reflective coating disposed on an outer surface of the optical window
20 opposite the at least one sealed cavity.

18. The wafer-level package of claim 12 further comprising:

an anti-reflective coating disposed on an outer surface of the attached cap lens.

19. The wafer-level package of claim 1 further comprising:

a transparent conductive layer disposed on the inner surface of the optical window.

20. The wafer-level package of claim 1, wherein the optical window attached to the substrate surface forms a plurality of sealed cavities.

21. A wafer-level package for a micromirror array, the wafer-level package comprising:

a substrate comprising a wafer having a substrate surface;

a plurality of actuatable micromirrors coupled to the substrate surface; and

an optical window attached to the substrate surface to form a plurality of sealed cavities between an inner surface of the optical window and the substrate surface, wherein a beam of light transmitted through the optical window is redirected by at least one actuatable micromirror within one of the plurality of the sealed cavities.

22. A method of packaging an array of actuatable micromirrors, the method comprising:

providing a substrate comprising a wafer having a substrate surface and a plurality of actuatable micromirrors coupled to the substrate surface;

providing an optical window; and

attaching the optical window to the substrate surface to form at least one sealed cavity between an inner surface of the optical window and the substrate surface, wherein a beam of light transmitted through the optical window is redirected by at least one actuatable micromirror within the at least one sealed cavity.

23. The method of claim 22, wherein the provided optical window comprises one of a glass wafer or a silicon wafer.

24. The method of claim 22, wherein attaching the optical window to the substrate surface comprises forming one of a solder bond, a thermocompression bond, or a wafer-to-wafer bond between the optical window and the substrate surface.

25. The method of claim 22 further comprising:
molding at least one recess into the optical window to form at least a portion of the at least one sealed cavity.

26. The method of claim 22 further comprising:
plating a spacer onto the inner surface of the optical window prior to attaching the optical window to the substrate surface, wherein the plated spacer increases a cavity height within the at least one sealed cavity.

27. The method of claim 22 further comprising:

forming a cap reflector on the inner surface of the optical window or on a surface of the optical window opposite the at least one sealed cavity prior to attaching the optical window to the substrate surface.

5 28. The method of claim 22 further comprising:
attaching a cap lens to the optical window on a surface of the optical window opposite the at least one sealed cavity.

10 29. The method of claim 28 further comprising:
forming a cap reflector on a surface of the cap lens between the cap lens and the optical window.

30. The method of claim 28 further comprising:
attaching a transparent shim between the cap lens and the optical window.

15 31. The method of claim 30 further comprising:
forming a cap reflector on a surface of the transparent shim.

20 32. The method of claim 22 further comprising:
depositing an anti-reflective coating on the inner surface of the optical window.

33. The method of claim 22 further comprising:

depositing an anti-reflective coating on a surface of the optical window
opposite the at least one sealed cavity.

34. The method of claim 28 further comprising:

depositing an anti-reflective coating on an outer surface of the cap lens.

35. The method of claim 22 further comprising:

depositing a transparent conductive layer on the inner surface of the optical
window.

36. The method of claim 22 further comprising:

dicing the substrate and the attached optical window to form a plurality of
packaged micromirror arrays.

37. A micromirror assembly, the micromirror assembly comprising:

a diced substrate having a substrate surface;

a plurality of actuatable micromirrors coupled to the substrate surface; and

an optical window attached to the substrate surface to form a sealed cavity

between an inner surface of the optical window and the substrate surface, wherein the sealed
cavity was formed prior to dicing of the substrate, wherein a beam of light transmitted
through the optical window is redirected by at least one actuatable micromirror within the
sealed cavity.

38. The micromirror assembly of claim 37, wherein each micromirror is coupled to the substrate with at least one vertical comb drive electrostatic actuator.

39. A system, the system comprising:

5 a wafer-level package for a micromirror array, the wafer-level package including a substrate having a substrate surface, a plurality of actuatable micromirrors coupled to the substrate surface, and an optical window attached to the substrate surface to form a plurality of sealed cavities between an inner surface of the optical window and the substrate surface; wherein a beam of light transmitted through the optical window is
10 redirected by at least one actuatable micromirror within one of the plurality of sealed cavities.

40. The system of claim 39, wherein each micromirror is coupled to the substrate with at least one vertical comb drive electrostatic actuator.